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Growth Performance of African Catfish (*Clarias gariepinus* Burchell 1822) Reared in Fertilized Ponds

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Abstract

Organic manures can be applied to fish ponds receiving no/limited feed supplements to augment plankton growth. The present study evaluated the growth performance and survival rate of African catfish (Clarias gariepinus) reared in ponds fertilized with organic manures: cow dung (CD) at 20 kg/100 m^2, chicken manure (CM) at 10 kg /100 m^2 every 15 days and with formulated feed as a control (FF) at 3 to5% of the fish live body weight. Six concrete walled earthen floor ponds (50 m^2) were stocked at 2 fish/ m^2 each with mean initial weight ranging from 54 ± 1.1 g to 56.4 ± 1.1 g. The mean final weights of the fish were 125.3, 173.1 and 193.2 g in CD, CM and FF, respectively. The daily growth rates were 0.28, 0.47 and 0.56 g/day for fish reared with CD, CM and FF, respectively. Survival rates of fish reared with CD, CM and FF were 71.1, 81.1 and 92.6%, respectively. There was no significant difference (p>0.05) in fish growth reared with CM and supplemented with FF. CM favored diverse phytoplankton growth (69 taxa) dominated by green algae and diatoms followed by CD (46 taxa) and FF (36 taxa). Partial economic analysis of the production cost revealed that growing fish using FF costed 3.8 fold higher than growing fish in fertilized ponds. Such semi-intensive type of catfish farming in fertilized ponds is both technologically and economically feasible for backyard fish farming. Further research should focus on fish stocking densities and fertilization rates to optimize water quality and fish growth.

Keywords: Formulated feed; fish growth; organic manures; plankton diversity; weight gain

Introduction

African catfish, *Clarias gariepinus* is among the top ten major cultured finfish species produced worldwide (FAO, 2022). The top producing countries are Nigeria followed by the Netherlands (FAO, 2016; Dauda *et al*., 2018). The African catfish is one of the most important cultured fish species in developing countries such as Nigeria (Nwanna, 2002; Adewolu & Adoti, 2010; Abalaka *et al*., 2015), Uganda (Isyiagi *et al*., 2009), Tanzania (Limbu *et al*., 2017), Kenya (Dasuki *et al*., 2013; Munguti *et al*., 2014), Cameroon (Yong-Sulem *et al*., 2006) and Democratic Republic of Congo (de Graaf & Janssen, 1996). In all cases, the African catfish is cultured mainly in semi-intensive earthen ponds, which are mostly farmer owned (Karisa *et al*., 2013), while intensive tank culture is becoming more popular in peri-urban areas in Nigeria (Hecht, 2013). Its broader feeding habit, fast growth, tolerance to low oxygen concentration and adaptation to wide environmental condition makes the African catfish among the most cultured fish (Hecht *et al*., 1996; Marimuthu *et al*., 2010).

Fish feed remains the most expensive input in fish farming in most sub-Saharan African countries (Adéyèmi *et al.,* 2023). Our understanding on feed and nutrition is very important because fish feed accounts for 40-50% of the production costs of fish culture (Basharat *et al*., 2023). Presently, fish farming largely depends on imported feeds (Adéyèmi *et al*., 2020) for this reason many smallholder farmers in developing countries rely on pond fertilization to increase fish production (Boyd, 2018). One of the strategies to intensify fish farming in developing countries is to look for different options so that the fish farmers can easily adopt. Fertilization of aquaculture ponds is analogous to fertilization of pastures to increase forage for livestock and/or fertilization of agricultural land to increase crop production (Boyd, 2018). Decomposition of organic fertilizers by microorganisms releases plant nutrients (Boyd and Tucker, 1998) that increases productivity of phytoplankton which serve as the food of zooplankton and benthic animals. Plankton, detritus and benthos are food for fish and crustaceans (Mischke, 2012).

In practice, semi-intensive fish farming in earthen ponds require feeds that are designed to supplement available nutrients obtained from natural food organisms, such as plankton rather than providing all the necessary nutrients required for fish growth. The phytoplankton (Kang'ombe *et al*., 2006) and other natural food organisms have high nutritional value, that generally account for a large share of total fish growth and survival in semi-intensive earthen ponds (Abou *et al*., 2016). *C. gariepinus,* is a generalist omnivore that is known to feed on natural foods in both natural and captive environments (Carballo *et al*., 1995). African catfish are of great importance as they grow quickly, attain a large size with more flesh and few spines, and hence contribute to food security (Ogello *et al*., 2013).

African catfish is mostly cultured in earthen ponds (Deomedes, 2020) in semi-intensive culture where the fish benefit from organic and inorganic (chemical) fertilizers to increase primary production and ultimately fish yield (Gamal, 2008). This system could be useful and applicable in fish farms or fish culture stations where water supplies are readily available and water loss through evaporation or by seepage is replaced regularly. Traditionally, organic fertilizers such as animal manures (Beyerle, 1979), chicken litter (Knud-Hansen *et al*., 2003) and organic and inorganic fertilizers (Soderberg, 2012) have been used to fertilize fish ponds. However, the excessive application of organic manure into fish ponds can reduce dissolved oxygen and cause fish kills (Middleton and Reeder, 2003, Tew *et al.*, 2006). Apart from organic fertilizer, chemical fertilizer can be used as a source of nitrogen and phosphorous to fertilize fish ponds (Ibrahim and Nagdi, 2006) but it is mostly expensive for fish farmers. The semi-intensive fish farming can be integrated with the other agriculture practices like livestock-vegetable farming where the wastes from animals like cattle,chicken, pig and/or duck can be used to produce manure that is used to fertilize ponds with the aim of improving both primary productivity and zooplankton proliferation (Ogello *et al*., 2013) and hence fosters fish growth.

There is no compound feed in local market for African catfish in Ethiopia and importations of industrially manufactured feeds are often too expensive and not affordable by the rural fish farmers. Therefore, fertilization of ponds could be a means to stimulate production of planktons which serve as food for fish like African catfish. Hence, the objectives of this study were to evaluate the growth performance of African catfish and plankton communities in ponds fertilized with organic manures without feed supplements.

Materials and Methods

Study site

This study was conducted at National Fishery and Aquatic Life Research Center (NFALRC) –Sebeta (8º55.076’N; 38º38.161’E), located at an altitude of 2220 m above sea level. The experiment was conducted from March to December 2022. The annual rainfall and monthly temperature computed from daily measured meteorological data in NFALRC compound is presented in Fig. 1. There was rainfall throughout the year except in February, May and December and a decline in air temperature from May onwards in the area where the experiment was conducted.

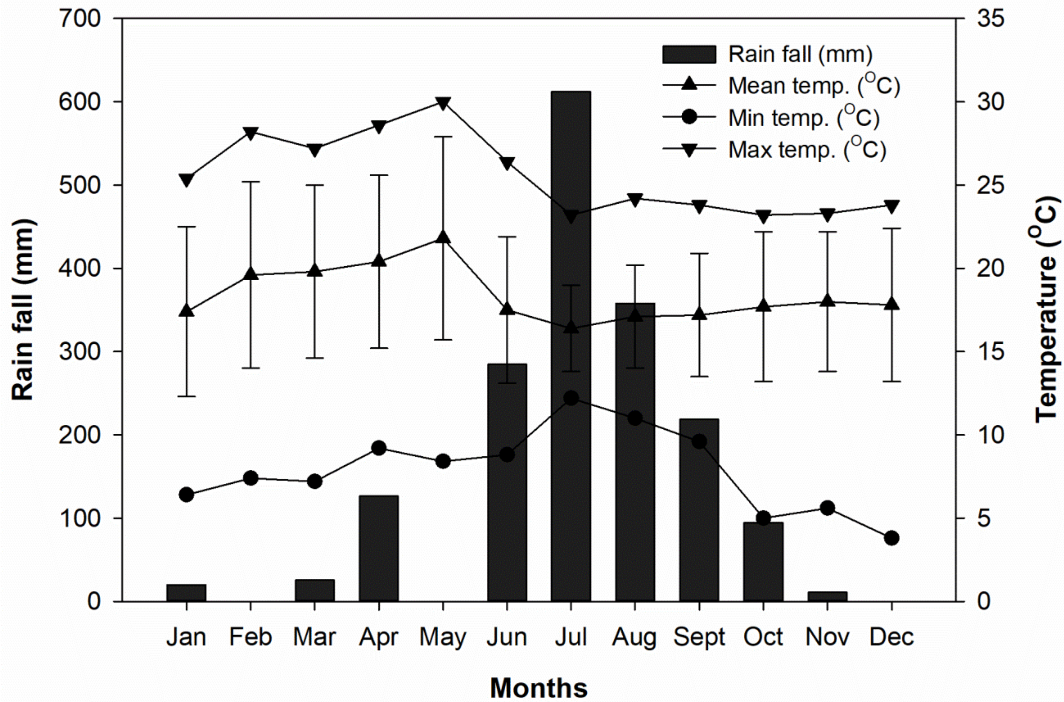

Fig. 1. Monthly total rainfall, mean, minimum and maximum air temperature at NFALRC-Sebeta compound during the experimental period

Experimental design and procedure

We used randomized block design where six experimental ponds each with an area of 100 m^2 and an average depth of 1.2 m (water level in ponds was kept at around 1 m depth) were randomly assigned for the three treatments: CD (cow dung) and CM (chicken manure) where the fish fed only on natural foods stimulated by fertilization and FF (formulated feed) each with duplicates. Since we didn't have equal size ponds we used the average of the duplicates in each treatment as the 3rd replicate for the analysis.

Before the experiment was started, CM was spread over the pond bottom at 5 kg/100 m^2 and CD at 10 kg/ 100 m^2 as recommended by Tacon (1988) for African catfish ponds then the ponds were filled with water to a depth of 20 cm and to 1 m depth after a week. Then after 10 kg CM and 20 kg CD were applied every two weeks. No manure was added in the ponds for control (that receives formulated feed) but the water was filled. After two weeks catfish fingerlings obtained from NFALRC hatchery were stocked in the ponds assigned for each treatment at a stocking density of 2 fish per m^2. For the control group (FF) fish received formulated feed with 42% CP at 5% of their live body weigh per day for the first 3 months and 3% of their live body weight for the remaining seven months. The amount of formulated feed was adjusted monthly by measuring the body weight of 50% of the fish stocked from each replicate.

To generate data for fish growth parameters, total length and total weight of 50% of the stocked fish were measured every month, and then returned to their respective ponds immediately. Total length and total weight were measured to the nearest 0.1 centimeter and 0.1 gram, respectively. About 20% of the pond water was refreshed with fresh water every 3 days to improve water-quality parameters. During the daily monitoring dead fish were counted for survival rate calculation. At the end of the experiment, all fish in each treatment were harvested, length-weight measurement taken and counted. Length-weight relationship of *C. gariepinus* was calculated using least square regression analysis as in Bagenal and Tesch (1978). Parameters like mean weight gain, daily weight gain, specific growth rate, condition factor, feed conversion ratio (for the control group) and survival rates were calculated as follows.

$$\text{Mean weight gain (g/fish)} = W_f - W_i \qquad (1)$$
$$DWG = (W_f - W_i)/\, t \qquad (2)$$
$$SGR\ (\%\ day^{-1}) = (\ln W_f - \ln W_i)\ /\ t \times 100 \qquad (3)$$
$$FCR = TFC\ /TWG \qquad (4)$$
$$\text{Survival (\%)} = (\text{Number of fish at final harvest / Number of fish at initial stocking}) * 100 \qquad (5)$$
$$K = W/\ L^3 \times 100 \qquad (6)$$
$$W = aL^b \qquad (7)$$

Where W_f is mean final weight, W_i is mean initial weight in gram, t is growing period in days, DWG is daily growth rate in g/day, SGR is specific growth rate (%/day), FCR is food conversion ratio, k= Fulton's condition factor, W = weight (g) and L =total length (cm), a & b are regression coefficients

To calculate the partial cost of production we considered labour, fish fingerling costs at 3 Ethiopian Birr per fingerling and feed costs. For feeding the fish twice a day and collecting organic manures twice a month to apply in the ponds, a labor cost of 25 Ethiopian Birr per month was considered. The fish feed (control) cost was calculated by multiplying the total feed by the price per kilo referred from the receipts from finance and procurement team. To calculate the gross revenue fillet which is 55% of whole fish (Okomoda *et al*., 2021) and a price of 200 Ethiopian Birr/kg were considered.

Water quality parameters (water temperature, DO, pH, conductivity) of the experimental fish ponds were measured *in-situ*. To examine the diversity of natural fish food in the ponds, integrated plankton samples were collected using plankton nets of 20 µm mesh size for phytoplankton and 55 µm mesh size for zooplankton by towing horizontally and vertically. Filtered water samples were immediately taken to NFALRC laboratory for live taxonomic identification to the genus and species level whenever possible using identification keys (i.e. Koste 1978; Fernando 2002; Linne von Berg and Melkonian 2004, Guiry and Guiry, 2024). The species composition and relative abundance of plankton were examined under microscope for each treatment.

Data analysis

Statistical analysis was carried out on all data using Sigma plot version 12. Data were pooled by treatment and presented as mean $\pm$ standard deviation (SD). Data were analyzed for treatment effect by one way analysis of variance (ANOVA). The Turkey Post hoc test was used with 95% confidence level to check which means are significantly different from each other at $p \leq 0.05$.

Results and Discussion

Growth performance and yield of *C. gariepinus*

The results for growth parameters such as mean final weight, daily weight gain, specific growth rate and percent survival values showed an increase along the treatments in the order CD<CM<FF (Table 2). The decline in the growth curve from July to October (Fig. 2) coincides with the decline in temperature evidenced in Figure 1. The daily growth rates for the fish grown in ponds fertilized with CM (0.47 g/day) and fish fed with formulated feed (0.56 g/day) are comparable with the reports from Tanzania, 0.4 g/day (Mosha *et al*., 2016), 0.34-0.55 g/day in tank culture at NFALRC Sebeta-Ethiopia (Abelneh Yimer *et al*. in press) and from Nigeria 0.68 g/day (Ajah *et al*., 2022). Otieno *et al*. (2021) reported very low daily growth rate of 0.08 g/day but a higher daily growth rate (1.3-1.5 g/day) was also reported for the same species in Kenya (Karisa *et al*., 2013). In addition to feed type, *C. gariepinus* is also affected by other factors like stocking density where a higher growth was reported with stocking density of 7 fish per m^2 (Vincent and Neill, 2019).

The feed conversion ratio for the control feed was comparable with the report by Karisa *et al*. (2013) that ranged from 2.9-3.44 although Abdel-Hay *et al*. (2019) reported a better feed conversion ratio of 1.6 from Egypt. On the other hand much lower feed conversion ratios 5 (Ajah *et al*., 2022) and 13.4 (Omodu *et al*., 2017) were also reported for *C. gariepinus*. The highest survival was recorded in the control group followed by ponds fertilized with chicken manure and the lowest from the pond fertilized with cow dung (Table 2). The highest mortality in the manure fertilized ponds compared with the control feed was because the fish were scrapping the sacks, entered and entangled inside. Immediately when we found out such mortalities during our daily monitoring, we mixed the dry manure with the respective pond water and spread the liquid manure over the ponds and no mortality was observed then after.

Table 1. Growth performance and yield parameters of African catfish (*Clarias gariepinus*) reared in fertilized ponds, and fed with formulated feeds

Parameters	Treatments		
	CD	CM	FF (Control)
Growth			
Initial weight (g)	54.6 ± 1.1	56.4 ± 1.1	53.9 ± 1.2
Final weight (g)	125.3 ± 4.7	173.1 ± 5.9	193.2 ± 5.9
Daily weight gain (g/day)	0.28	0.47	0.56
Specific growth rate (%/ day)	0.33	0.45	0.51
Fulton's condition factor (K)	0.64	0.72	0.72
FCR			2.98
Survival rate (%)	71.1	81.1	92.6
Fish yield parameters			
Production cost	850	850	1307.50
Total weight (kg/ha)	1781.8	2807.7	3578.1
Net fillet weight (kg/ha)	980	1544.2	1967.9
Net profit (at 200 ETB/kg)	195,144.26	307,2995.02	392, 279.55

Values are mean ± SE for three replicates. CD stands for Cow dung, CM for chicken manure, SGR for specific growth rate, FCR for feed conversion ratio and K for Fulton's condition factor.

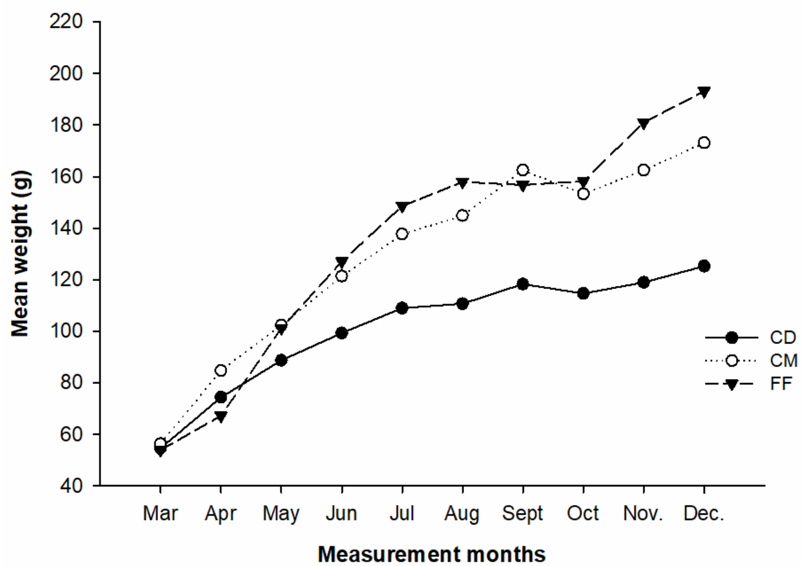

Fig. 2. Monthly mean growth trend of African catfish (*C. gariepinus*) reared in fertilized ponds and fed with formulated feed

For the experimental period, the costs for research inputs (fish fingerlings) and labour were 850 Ethiopian Birr for CD and CM but the cost for the control group

(FF) was 1307.5 Ethiopian Birr since it has feed cost in addition to the costs for fingerlings and labour. There was significant difference ($p<0.05$) in the production costs between the organic manure fertilized ponds and the control, the pond that received fish feed but not between CD and CM. Application of chicken manure significantly reduced production costs of African catfish by 3.8 fold lower when compared to growing the fish with formulated feed.

One way ANOVA showed that there was significant difference in fish growth among the treatment groups (Fig. 3). Fish grown in CD fertilized ponds showed significantly ($p= 0.007$) lower growth rate than the fish grown in CM fertilized ponds and ponds that received FF ($p=0.002$). This could be due to the fact that cattle manure decomposes slowly and hence natural fish feeds will take longer to develop (NACA, 1989). However, there was no significant difference ($p=0.9205$) in fish growth between fish grown in ponds fertilized with CM and ponds that received FF (Fig. 2). The reason for such variation in fish growth among the treatments is likely due to the difference in the nature of manure (Ashworth *et al*., 2019) and quality of the feed. The control feed, FF is well in the recommended range for CP% in the catfish diet where best growth was obtained with feed containing 40-58% CP for Clarias species (Rahman *et al*., 1997). For fish grown in ponds fertilized with CM could be due to the quality and availability of the natural fish feed in the ponds where out of the 69 phytoplankton species 46 (with 8 dominant) of them belong from Chlorophta (green algae) and Bacillariophyta (diatoms) which are considered preferable in aquaculture ponds (Mischke, 2012). On the other hand, lower growth of fish recorded in ponds fertilized with CD could be due to the dominance of Cyanobacteria (blue green) species (Table 3) generally considered less nutritious, less palatable and are less preferable over green algae and diatoms (Mischke, 2012).

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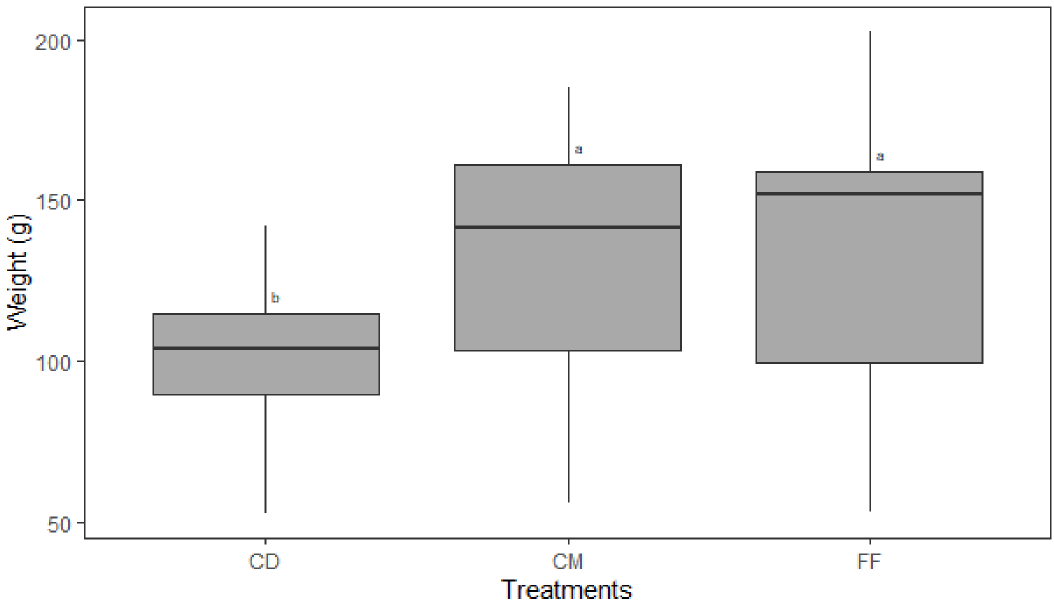

Fig. 3. Boxplots of *C. gariepinus* body weight variation among treatments (different letters indicate significant difference between treatments at $p<0.05$)

The regression analysis of the length-weigh relationship of the fish showed that *C. gariepinus* grown in manure fertilized ponds and fish fed with formulated feed exhibited negative allometric growth pattern with 'b' value less than 3 (Fig. 4). The b values obtained in this study are larger than the report by Ronald (2021) with b vale 2.08 for the same species. Our result on b from the culture experiment is comparable with reports of b values from the natural lakes for the same species: 2.9 from Lake Tana (Abebe Amha *et al*., 2006) and 2.8 from Lake Lugo (Endalh Mekonnen *et al*., 2019) which indicates that the fish did not grow symmetrically that is in agreement with the report by King (1996) who found that fish becomes slender with the increase in their length.

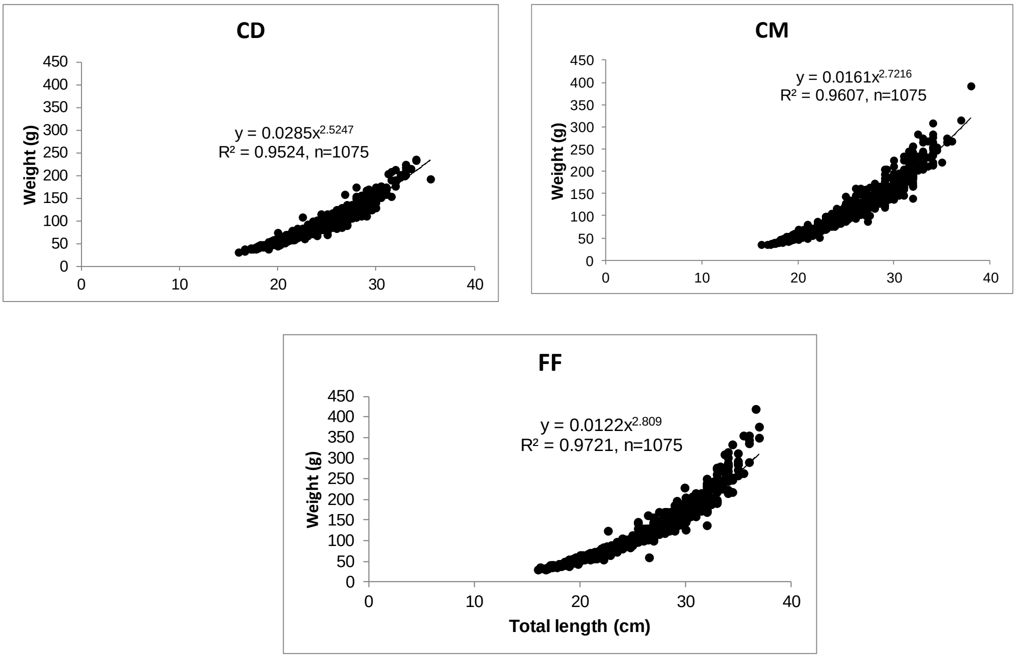

Fig. 4. Length weight relationship of *C. gariepinus* grown in fertilized ponds

Determination of some physicochemical parameters of pond water

The water temperature of experimental ponds ranged between 17.8 and 27.8 ^{O}C with a mean of 22 ^{O}C over the experimental period. There was no significant difference (p=0.997) in water temperature of ponds among the treatments. However, there was significant difference (p=0.001) along the culturing periods which was expected as the rearing period covers both the dry and rainy seasons. pH measurement was rather similar among the treatments during the experimental period ranging between 7.4 and 9 with a mean of 8.6. On the other hand, dissolved oxygen showed significant difference (p=0.002) between the treatments. This is due to the accumulation of organic matter that requires more oxygen for decomposition. This is in agreement with the report by Lorimore (2004) who found that dairy and beef cattle manure require from 0.15–0.22 kg O_2/kg of manure but manure from chicken requires more oxygen (0.53–0.57 kg O_2/kg) for decomposition. According to NACA (1989) cattle excreta also decomposes more slowly than chicken manure, thus requires longer time for the algae to develop. The statistical test also revealed this fact in that there was a declining trend in DO over the culturing period. DO at the start of the experiment was significantly different (p=0.007) from the measurements taken after six and (p=0.003) nine months of culturing. The DO recorded after three culturing months was not significantly different (p=0.154) from six months of culturing but was significantly different (p=0.049) between the measurements taken after nine months. Moreover, there was no significant difference (p=0.844) in DO recorded between the six and nine months culturing periods. Unlike the DO there was no significant difference (p=0.814) in conductivity among of the culturing period but was among the treatments: between CD and FF (p=0.002) and between CM and FF (p=0.001) but there was no significant difference (p=0.822) in conductivity between CD and CM. This could be due to the fact that the manures were collected from the ground and there is a possibility of collecting some ions together with the soil which is not the case in the control.

Table 2. Mean $\pm$ SD concentrations of some water quality parameters of treatments at different times after stocking

Treatments	Parameters	Measurements			
		Initial	After 3 months	After 6 months	After 9 months
CD	Water temp. (^{O}C)	23.3 ± 0.3^{a}	21.8 ± 0.5^{b}	20.3 ± 1.1^{c}	21.2 ± 0.4^{cb}
	DO (mgl^{-1})	10.2 ± 0.3^{a}7.	4 ± 0.8^{ba}	3.4 ± 0.8^{cb}	2.3 ± 0.6^{c}
	Cond. (µScm^{-1})	218.5 ± 2.7^{a}	211.5 ± 3.4^{a}	267 ± 2.5^{a}	245 ± 3.2^{a}
CM	Water temp. (^{O}C)	23.2 ± 0.4^{a}	21.5 ± 0.6^{b}	20.9 ± 0.5^{c}	21 ± 0.3^{bc}
	DO (mgl^{-1})	8.6 ± 0.5^{a}	6.3 ± 0.8^{ba}	$2.6 \pm 0.2b^{c}$	2 ± 0.5^{c}
	Cond. (µScm^{-1})	250.9 ± 7^{a}	245.7 ± 3.7^{a}	282 ± 4.6^{a}	265 ± 5.4^{a}
FF	Water temp. (^{O}C)	23.1 ± 0.3^{a}	21.6 ± 0.5^{b}	20.8 ± 0.7^{c}	21.3 ± 0.5^{cb}
	DO (mgl^{-1})	10.2 ± 0.3^{a}	7.2 ± 0.7^{ba}	6.4 ± 0.3^{c}	5.2 ± 0.8^{c}
	Cond. (µScm^{-1})	155 ± 7^{b}	157.5 ± 3.4^{b}	183.5 ± 2.7^{b}	192 ± 3.8^{b}

Plankton diversity of experimental ponds

To examine the natural food of fish available in ponds, identification of the plankton communities was conducted. A total of 83 algal taxa were identified from the fish rearing ponds (Table 3). The highest numbers of phytoplankton taxa were identified from ponds fertilized with CM (69) of which 10 taxa were dominant and 8 taxa were commonly found in the samples followed by CD (47) of which one taxon was dominant and three taxa were commonly found. The lowest numbers of phytoplankton genera (36 taxa) were identified from the control of with three species were commonly found. Highest numbers of phytoplankton taxa (32) were from Chlorophyta, followed by Bacillariophyta (18), Cyanobacetria (15), Charophyta (9), Euglenophyta (7) and Dinoflagellata (1) as indicated in table 3. On the other hand, 26 rotifers, 5 cladoceran and 2 copepod taxa were also recorded with the highest number of rotifer taxa in CM and FF (Table 4).

Table 3. Phytoplankton taxa identified in the treatments

Groups/taxa	Treatments			Groups/taxa	Treatments		
	CD	CM	FF		CD	CM	FF
Charophyta				**Cyanobacteria**			
Closterium dianae	-	+	+	*Anabaena circinalis*	+**	-	-
Closterium sp.	+	+	+	*Anabaena* sp.	+	-	-
Cosmarium contractum	-	-	+	*Anabaenopsis* sp.	+	-	-
Cosmarium sp.	-	+	-	*Aphanocapsa* sp.	+**	+	
Mougeotia scalaris	+	+*	-	*Aphanothece* sp.	-	+*	+
Mougeotia sp.	+	+	-	*Chroococcus turgidus*	-	+*	-
Staurastrum sp.	+	-	-	*Chroococcus* sp.	+	+	+
Staurastrum tetracerum	+	-	-	*Cylindrospermum sp.*	-	+	-
Spirogyra sp.	+	+	+	*Microcystis aeruginosa*	+**	+*	-
Chlorophyta				*Microcystis panniformis*	+	-	-
Ankistrodesmus babraianus	+	+**	+	*Microcystis wesenbergi*	+	-	-
A. densus	-	+**	+	*Microsystis* sp.	+	+*	+
Ankistrodesmus sp.	+	+**	+	*Merismopedia gluaca*	-	+	-
Acinastrum hantzschii	+	+	+	*Merismopedia tenuissima*	-	+	-
Acinastrums sp.	+	+	+	*Rhaphidiopsis* sp.	+	+*	+
Botryococcus sp.	-	+	-	**Bacillariophyta**			
Chodatella sp.	-	+	-	*Achnanthes* sp	+	-	-
Coelastrum sp.	+	+**	+	*Aulacoseira granulate*	+**	+**	+*
Crucigenia rectangularis	-	+	+	*Aulacoseira* sp.	+	-	-
Crucigenia sp.	-	+	+	*Cyclotella meneghiniana*	-	+	+
Eudorina sp.	-	+*	+	*Cymbella* sp.	-	+	-
Golenkinia radiate	-	+	+	*Diadesmis* sp.	+	-	-
Kirchneriella sp.	+	+	+	*Epithemia* sp.	-	+	-
Micractinum pusillum	-	+	+	*Gomphonema*			
				Telegraphicum	-	+	+
Micractinum sp.	-	+	-	*Gomphonema* sp.	-	+	-
Monorophidium griffithi	-	+	-	*Navicula* sp.	+	+	+
Monorophidium sp.	-	+	-	*Nitzschia dissipata*	-	+	-
Nephrocytium lunatum	-	-	+	*N. linearis*	+	+	-
Oocystis lacustris	-	+	-	*Nitzschia* sp.	+	+*	+
Oocystis sp.	-	+	-	*Pinnularia* sp.	+	+	-
Pandorina morum	-	+	-	*Rhopalodia gibba*	+	+	-
Pediastrum boryanum	+	+	+	*Surirella* sp.	+	+	+
Pediastrum duplex	+	+	+	*Synedra ulna*	+	+	+*
Pediastrum simplex	+	+**	+	*Tetraedriella patiens*	-	+	-
Scenedesmus abundans	+	+	+	**Euglenophyta**			
Scenedesmus acuminatus	+	+**	-	*Euglena acus*	+*	-	-
Scenedesmus bijugatus	+	-	-	*Lepocinclis ovum*	-	+	-
Scenedesmus opoliniensis	-	+	-	*Lepocinclis* sp.	+	+	+
Scenedesmus sp.	+	+**	+	*Phacus pleuronectes*	+	-	-
Selenastrum sp.	-	+	-	*Phacus* sp.	-	+	-
Tetraedron minimum	+	+	-	*Trachelomonas aspera*	-	+	-
Tetraedron triangulare	+	+	+	*Trachelomonas* sp	+	+	+
Dinoflagellata							
Peridinium cinctum	+	+**	-				

-indicates absence of the species in the identification, + present, +* commonly found and +** is dominant

Table 4. Zooplankton taxa identified in the treatments

Groups/taxa	Treatments			Groups/taxa	Treatments		
	CD	CM	FF		CD	CM	FF
Rotifers				**Cladocernas**			
Anuraeopsis fissa	-	+**	+	*Chydorus ovalis*	+**	+	+**
Lepadella sp.	+	+	+	*Chydorus* sp.	+*	+	+
Anuraeopsis sp.	-	+	+	*Diaphanosoma excisum*+		+	+**
Asplanchna priodonta-	+**	-		*Diaphanosoma* sp.	+	+	+
Asplanchna sp.	+	+**	+	*Moina micrura*	+	+	+
Brachionus angularis	+**	+	+	**Copepodes**			
Brachionus calyciflorus	+	+*	+	*Mesocyclops* sp.	+	+	+**
Brachionus plicatilis	+	-	-	*Thermocyclops* sp.	+**	+	+**
Brachionus sp.	+	+	-				
Conochilus hippocrepis-	+	-					
Filinia longiseta	+**	+*	+				
Hexathra oxyuris	-	+**	+				
Keratella cochlearis	+	+	+				
K. tropica	+	+	+				
Lecane luna	-	+	+				
L. lunaris	-	+	+				
Epipanes sp.	-	+**	+				
Polyarthra vulgaris	+	-	+				
Polyarthra sp.	+	-	-				
Philodina sp.	-	-	+				
Rotatoria rotatoria	-	+	-				
Trichocerca pussilla	-	+	+				
Trichocerca sp.	+	+	+**				

-indicates absence of the species in the identification, + present, +* commonly found and +** is dominant

The variation in the algal diversity in the experimental ponds could be due to the differences in the concentrations of key nutrients like nitrogen and phosphorous in the ponds that trigger algal development and growth. The concentrations of nitrogen and phosphorous are generally higher in chicken manure compared to other animals like horses and cattle (Sharpley *et al*., 2009; Brown, 2013) that justifies for the high diversity of phytoplankton species in general and for the dominance of good algal species in ponds fertilized with CM. The other likely justification for the variation in the algal species could be the variation in carbon concentration in organic manures. According to Brown (2013) the carbon concentration in dairy cattle manure is 9.2% but it is 25.8% in chicken litter (Sharpley *et al*., 2009).

Conclusions and Recommendations

In this study, growth and survival of African catfish in ponds fertilized with organic manures without feed supplements and with formulated fish feed as a control were studied at National Fishery and Aquatic Life Research Center. Growth and survival of African catfish in ponds fertilized with chicken manure was not significantly different ($p>0.05$) from the fish grown with formulated feed (the control). However, fish grown in ponds fertilized with cow dung was significantly different ($p<0.05$) from the fish growth both in ponds fertilized with chicken manure and ponds that received formulated feed. The daily growth rates were 0.28, 0.47 and 0.56 g/day for fish reared with CD, CM and FF, respectively. Survival rates of fish reared with CD, CM and FF were 71.1, 81.1 and 92.6%, respectively. Chicken manure fertilized ponds also favored diverse natural fish food, the phytoplankton taxa, both in abundance and in quality where 46 out of the 69 phytoplankton taxa (with 8 dominant) belongs from green algae and diatoms both groups considered as good fish food.

This study showed the importance of organic manure mainly chicken manure to fertilize ponds for rearing of African catfish. Using of chicken manure significantly reduced production costs of African catfish by 3.8 fold lower compared to growing the fish with formulated feed. Considering the availability of organic manure in most households and the low management interventions practiced by farmers, growing *C. gariepinus* in fertilized earthen ponds can be important management practice to be scaled up. However, more research should be conducted on the fish stocking densities, fertilization rates and regimes to optimize pond water quality and consequently fish production.

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